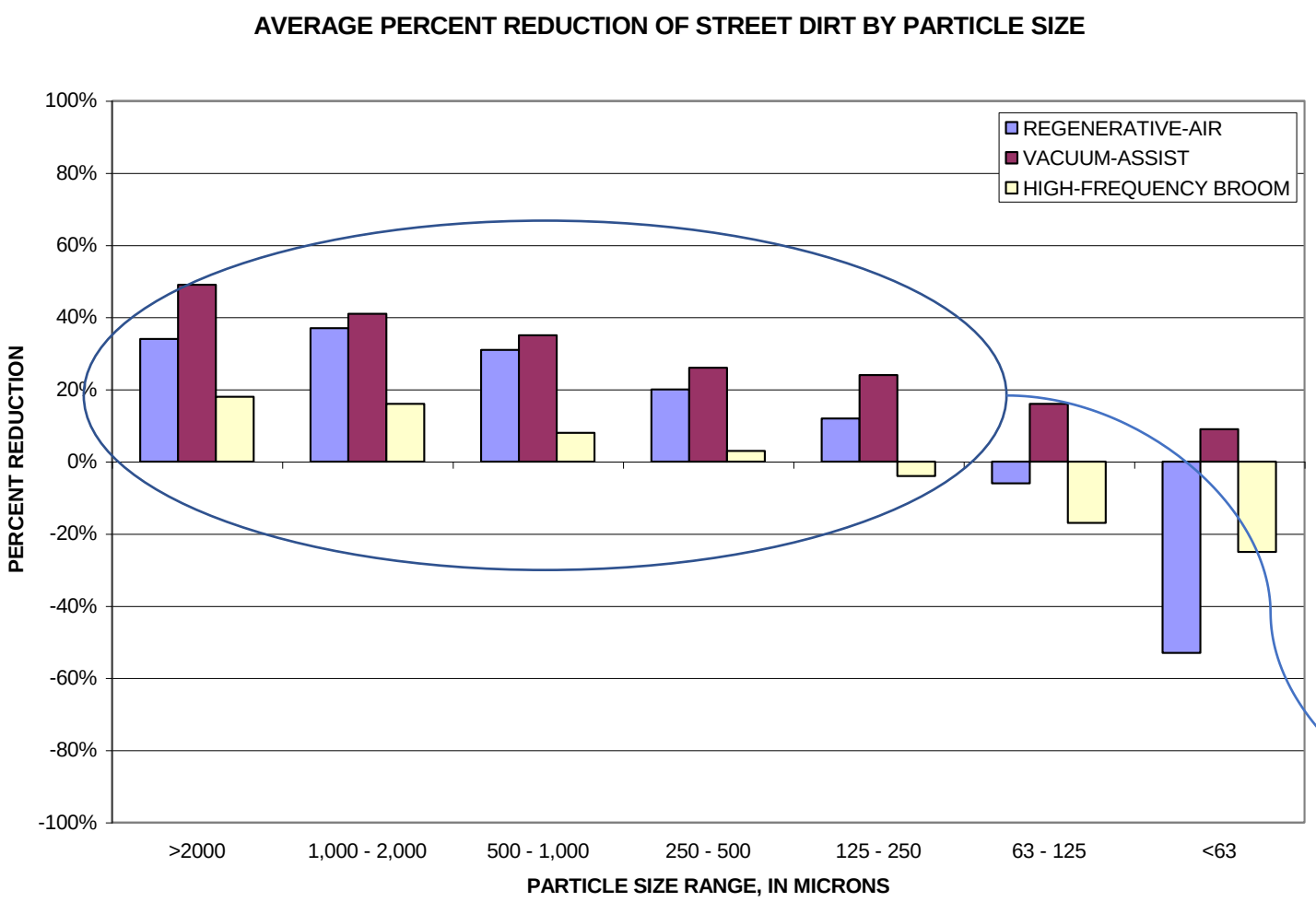
Phosphorus Reduction Credits for Street Sweeping and Leaf Collection:

- State of the science
- Future research

Bill Selbig
USGS – Upper Midwest Water Science Center
wrselbig@usgs.gov

For Street Dirt:
Cleaning Street ≠ Cleaning Runoff



Overall Street Dirt Removal Efficiency

Regenerative-Air	76%
Vacuum-Assist	62%
High-Frequency Mechanical Broom	20%
Low-Frequency Mechanical Broom	2%

<10% of mass found in stormwater runoff

Summer

Fall

April

May

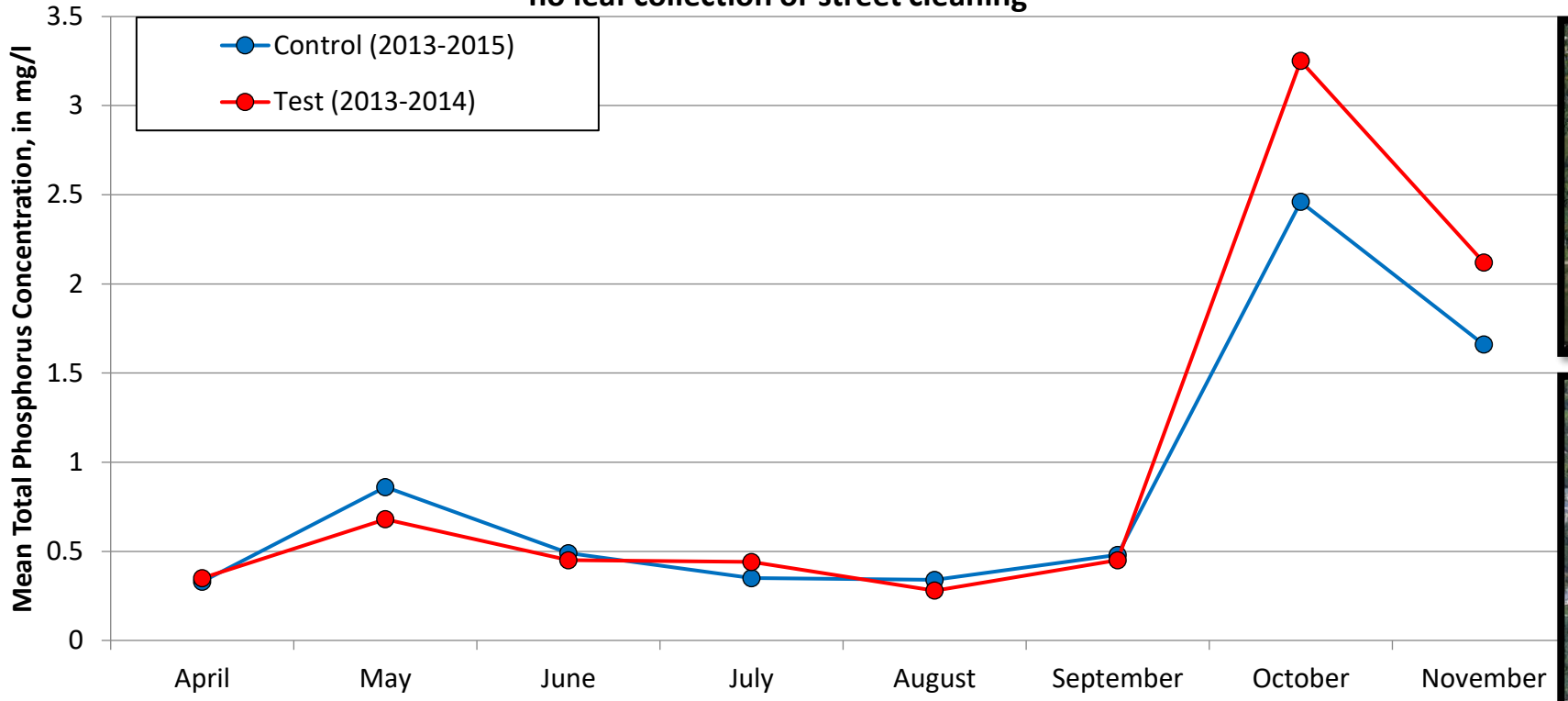
June-Aug

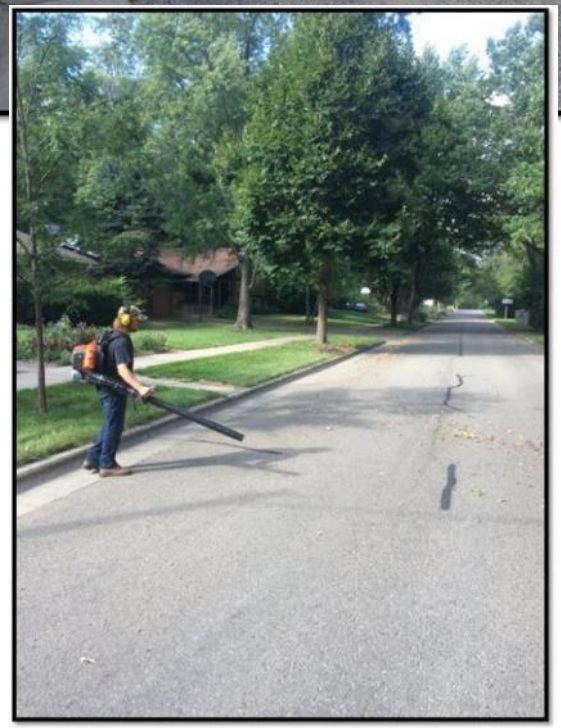
Sept

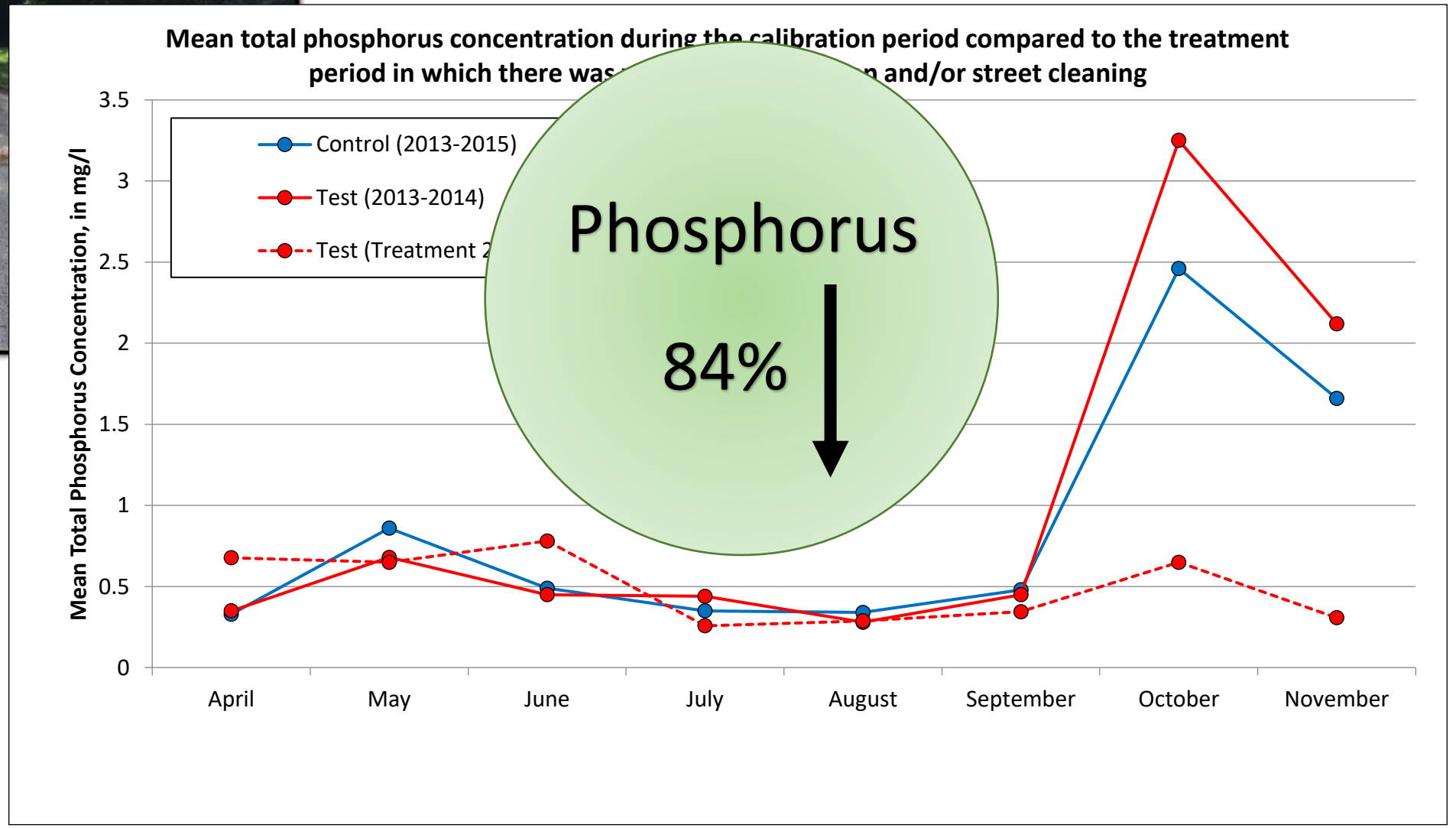
Oct

Nov

Mean total phosphorus concentration during the calibration period in which there was no leaf collection or street cleaning

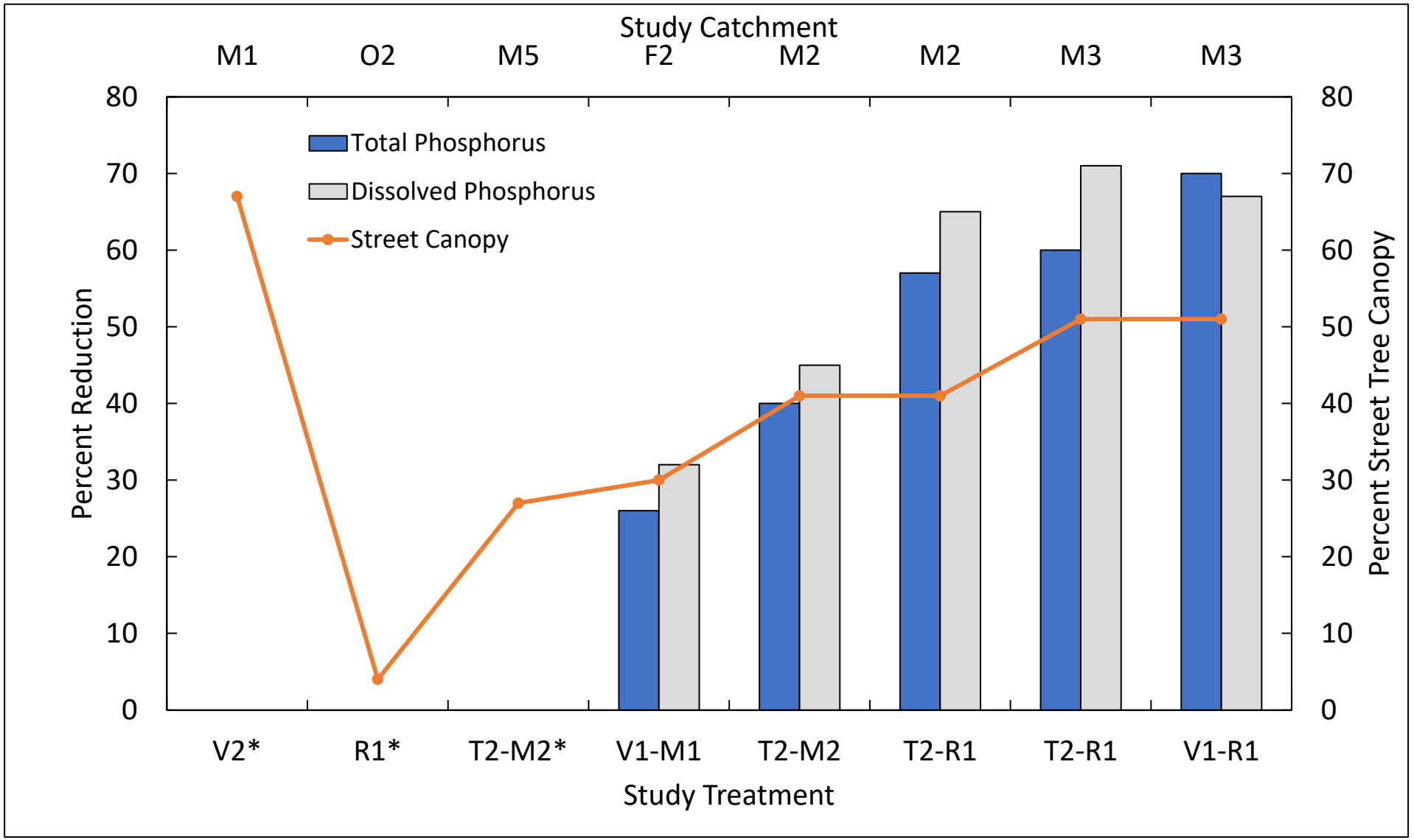




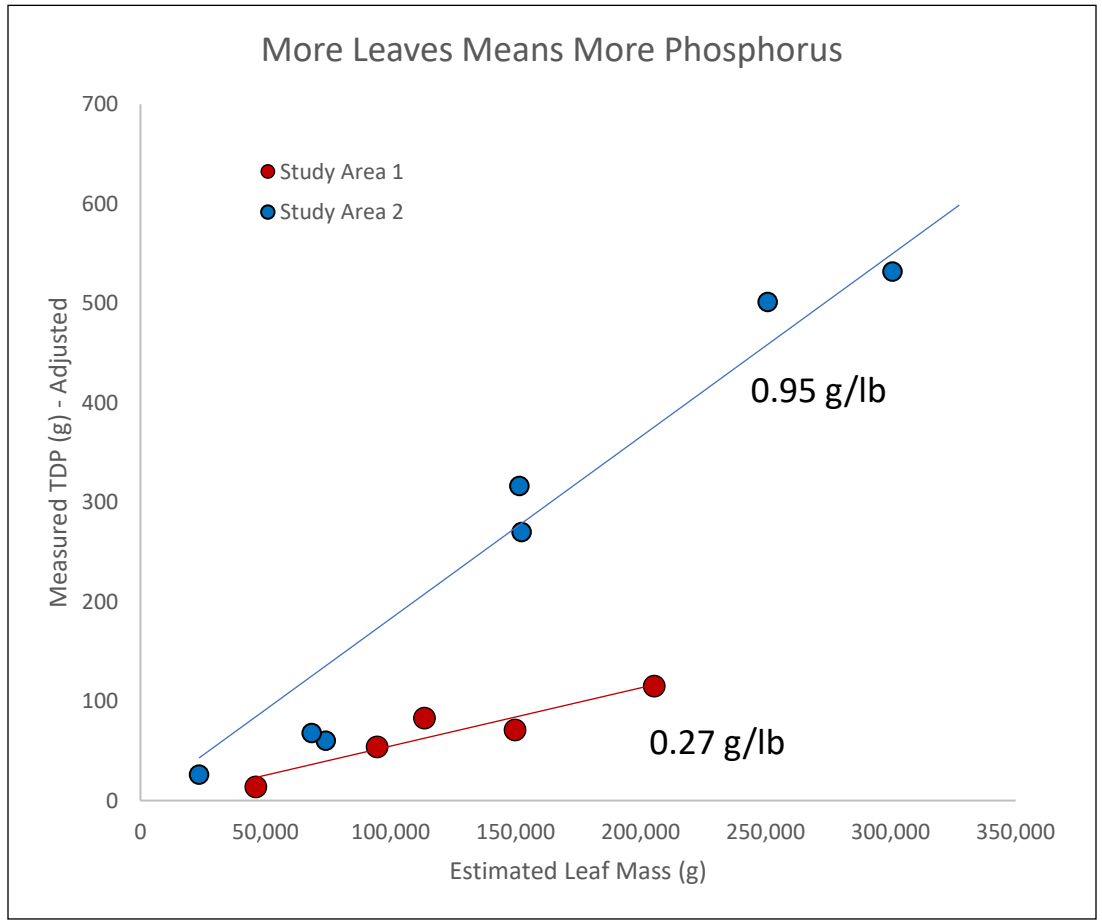

Mean total phosphorus concentration during the calibration period compared to the treatment period in which there was and/or street cleaning
Mean Total Phosphorus Concentration, in mg/l
3.5
3
2.5
2
1.5
1
0.5
0
Control (2013-2015)
Test (2013-2014)
Test (Treatment 2
April
May
June
July
August
September
October
November
Phosphorus
84%

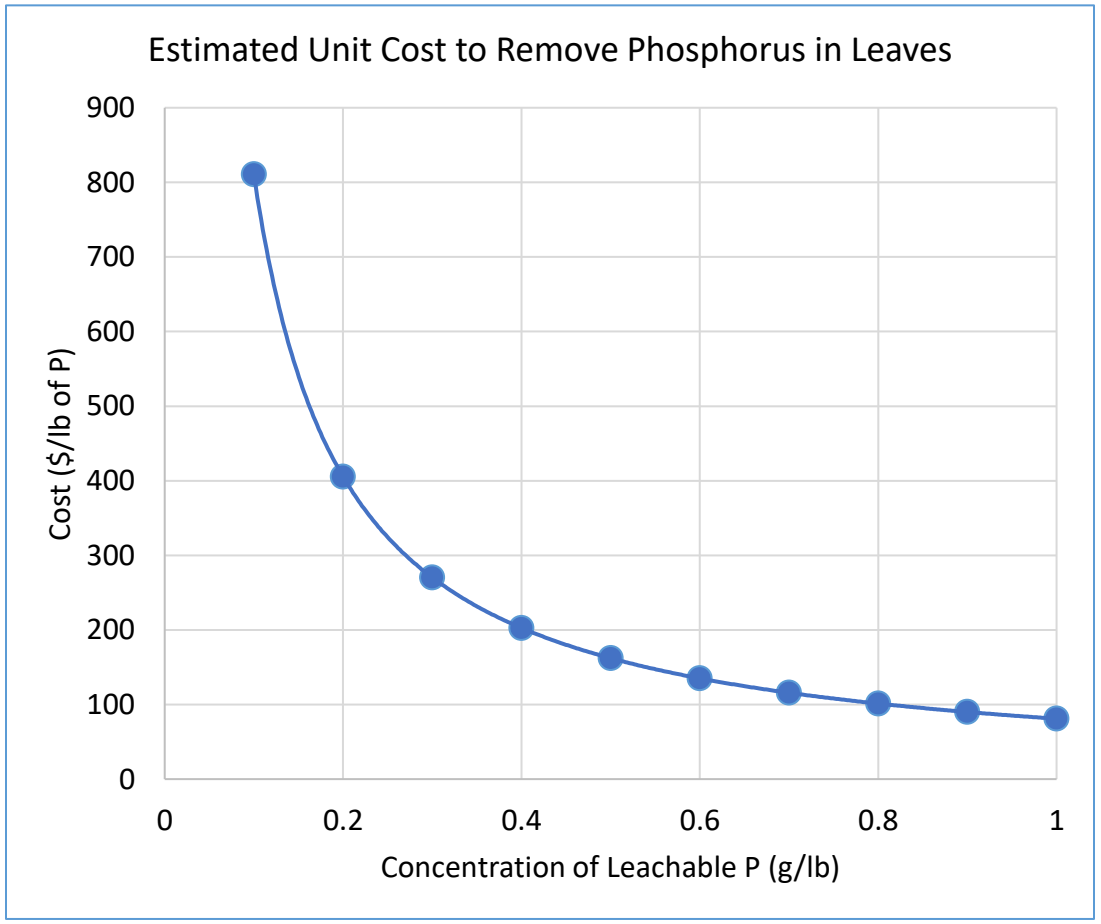

ELGIN Pelican


ELGIN Crosswind

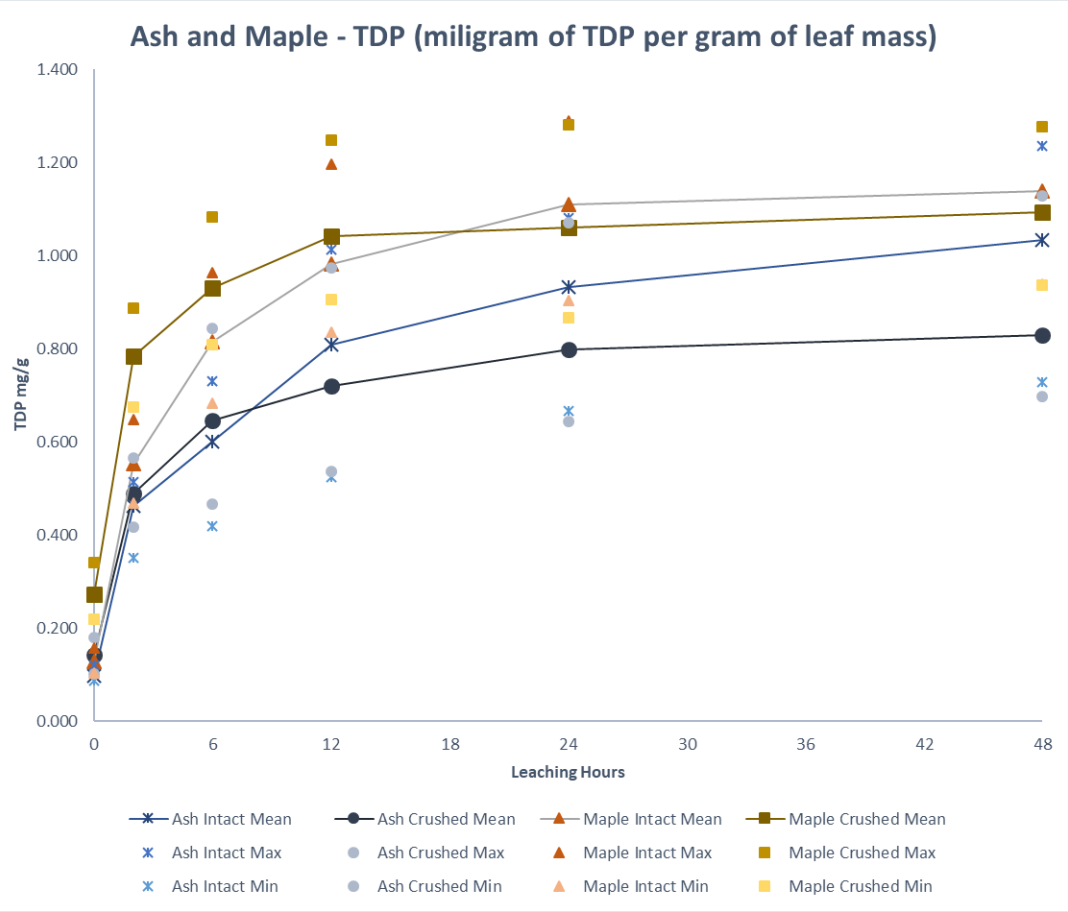

Study Catchment
M1
O2
M5
F2
M2
M2
M3
M3
Total Phosphorus
Dissolved Phosphorus
Street Canopy
Percent Reduction
Percent Street Tree Canopy
0
10
20
30
40
50
60
70
80
V2*
R1*
T2-M2*
V1-M1
T2-M2
T2-R1
T2-R1
V1-R1
Study Treatment

More Leaf Mass = More Phosphorus





Concentration varies by species



Midwest Region

Species	Places[1] (N)	Mean[2] (%)	SEM[3]
Acer platanoides	34	4.9	0.6
Acer saccharinum	37	4.7	0.7
Fraxinus pennsylvanica	31	4.3	0.5
Gleditsia triacanthos	48	4.2	0.3
Acer rubrum	25	2.5	0.3
Acer saccharum	17	1.1	0.1
Tilia cordata	11	0.7	0.1
Celtis occidentalis	12	0.7	0.1
Quercus palustris	7	0.7	0.1
Fraxinus americana	9	0.6	0.1

Ma et al. (2020)

What we know

- Leaves are a major source of urban phosphorus in the fall
- Amount of phosphorus in runoff is correlated to mass of leaves on street
- Concentration of phosphorus varies by species
- Frequent street cleaning and leaf collection can significantly reduce phosphorus in runoff
- Cleaning should be focused on street with less concern for leaf piles on terrace

What we're still learning...

Need Phosphorus for more tree species

TABLE 1

Leachable P, total P and % of total P leachable (and standard deviation) from urban street tree leaves and seeds

Species name		Leachable P	Total P	% of total P leachable	Number of samples	
Common name	Scientific name	µg gm^{-1}	%		Leachable P	Total P
Leaves						
Sugar Maple	Acer saccharum Marsh.	259.9(113.1)	0.20(0.032)	13.43(6.2)	6	3
Silver Maple	Acer saccharinum L.	232.7(117.6)	0.13(0.040)	17.7(6.3)	3	3
Green Ash	Fraxinus pensylvanica Fern.	188.4(75.1)	0.24(0.049)	7.0(0.43)	7	2
Honey Locust	Gleditsia tricanthos L.	176.0(101.1)	0.44(0.117)	4.5(2.3)	8	5
White Ash	Fraxinus americana L.	161.9(137.9)	0.14(0.042)	9.6(0.04)	4	2
American Elm	Ulmus americana L.	158.5(66.8)	n.d.[b]	n.d.	2	0
Basswood	Tilia americana L.	95.7(32.1)	0.15(0.045)	7.8(2.1)	5	3
Chinese Elm	Ulmus pumila L.	88.6(36.1)	n.d.	n.d.	2	0
Little Leaf Linden	Tilia cordata L.	86.5(22.5)	0.09 (n.d.)	6.7(n.d.)	3	1
Pin Oak	Quercus palustris Muenchh.	81.5(29.3)	n.d.	n.d.	2	0
Norway Maple	Acer platanoides L.	80.1(53.9)	0.08(0.035)	8.4(3.63)	5	2
Hessian Ash	Fraxinus excelsior L.	66.1(40.0)	n.d.	n.d.	3	0
Weeping Willow	Salix babylonica L.	38.1(1.1)	n.d.	n.d.	2	0
All Leaves		148.1(99.4)	0.22(0.147)	9.3(5.4)	52	21
LSD[a]		38.8	0.06	3.4		
Seeds						
Green Ash	Fraxinus pensylvania Fern.	77.6(n.d.)	0.26(n.d.)	3.0(n.d.)	1	1
Sugar Maple	Acer saccharum Marsh.	40.8(12.5)	0.35(n.d.)	1.4(n.d.)	2	1
Little Leaf Linden	Tilia cordata L.	39.2(11.6)	0.26(n.d.)	1.8(n.d.)	2	1
All Seeds		47.5(18.9)	0.29(0.052)	2.1(0.8)	5	3

[a] Least significant difference ($P \leq 0.05$).
[b] n.d. = not determined.

Dorney (1986)

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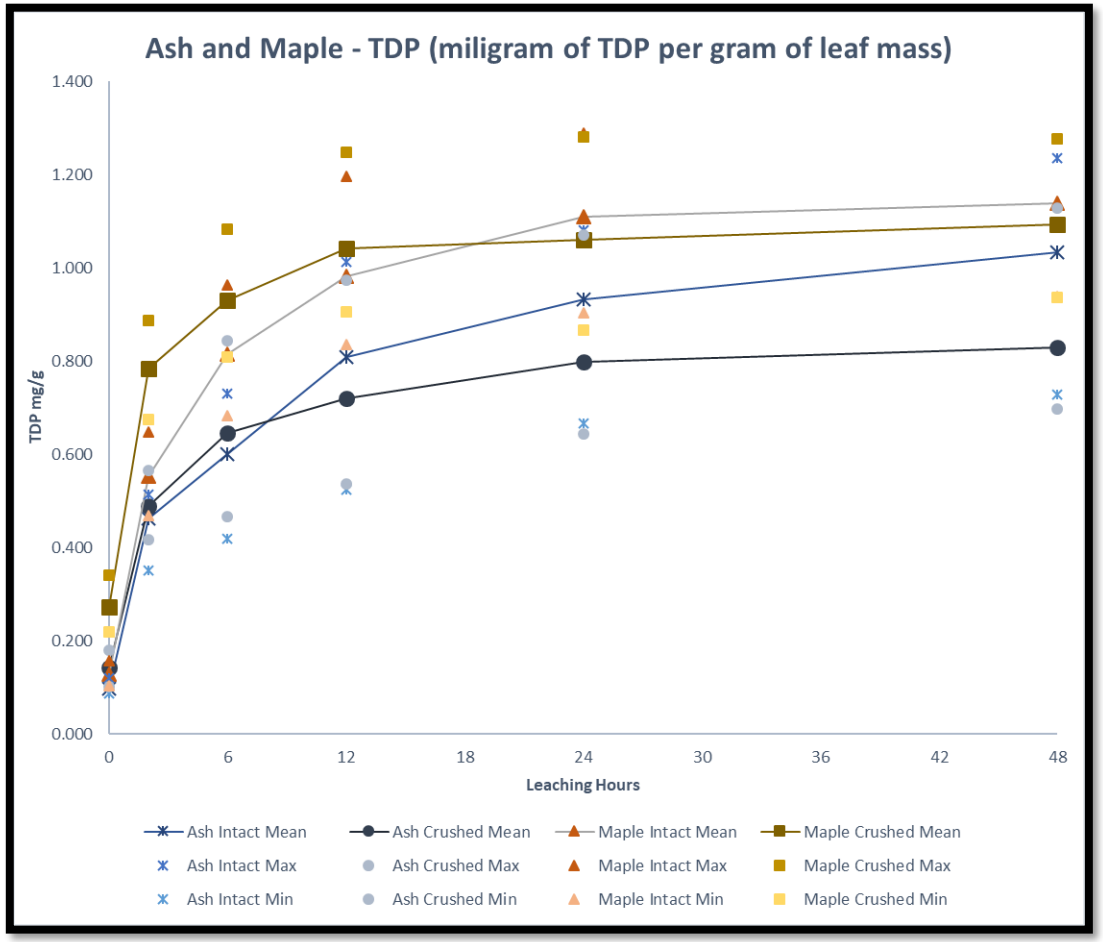

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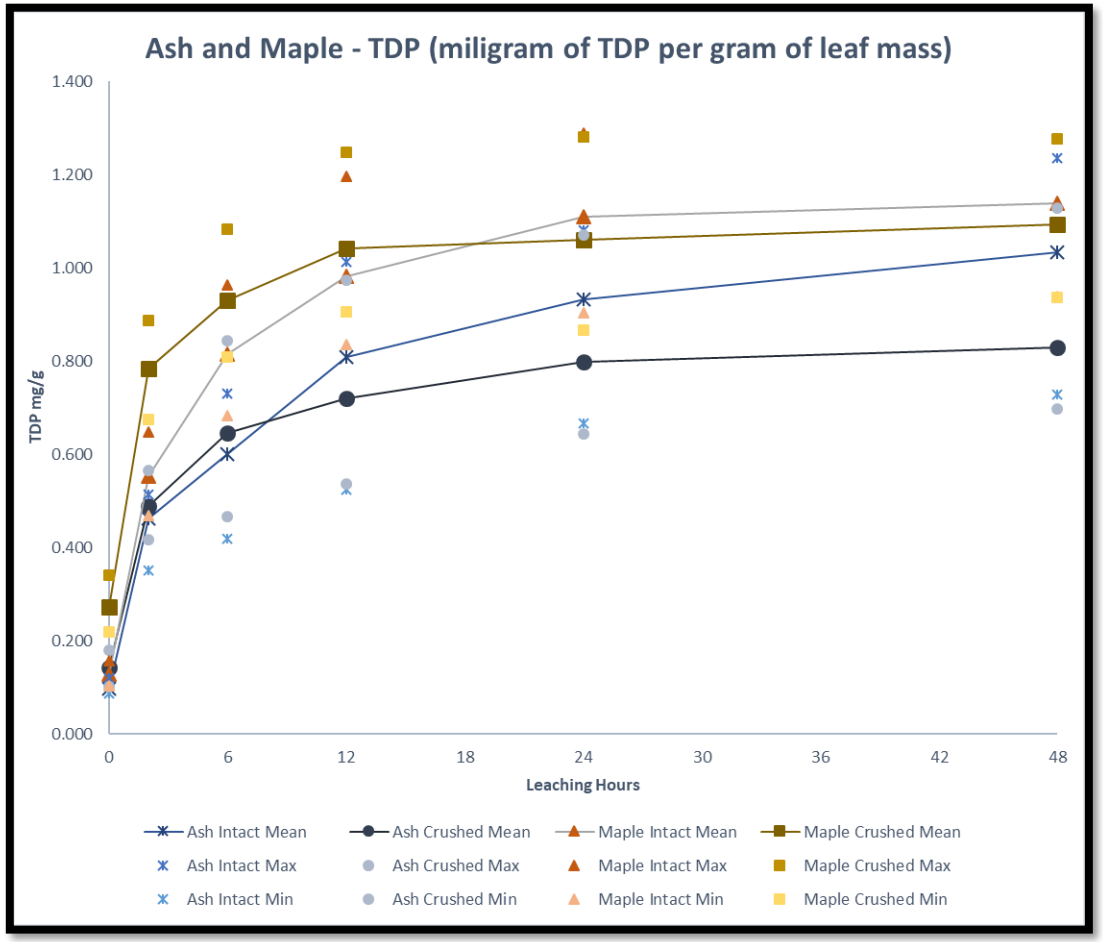
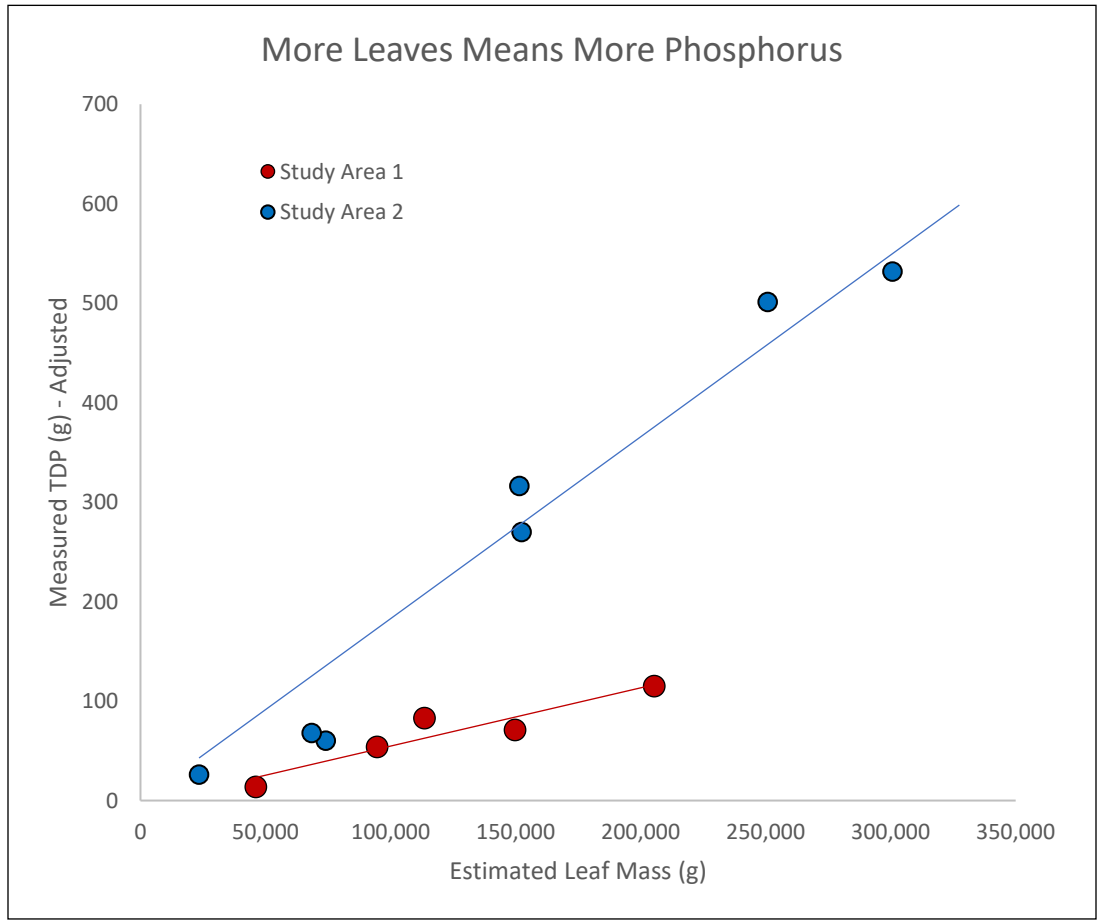


How best to incorporate into models?



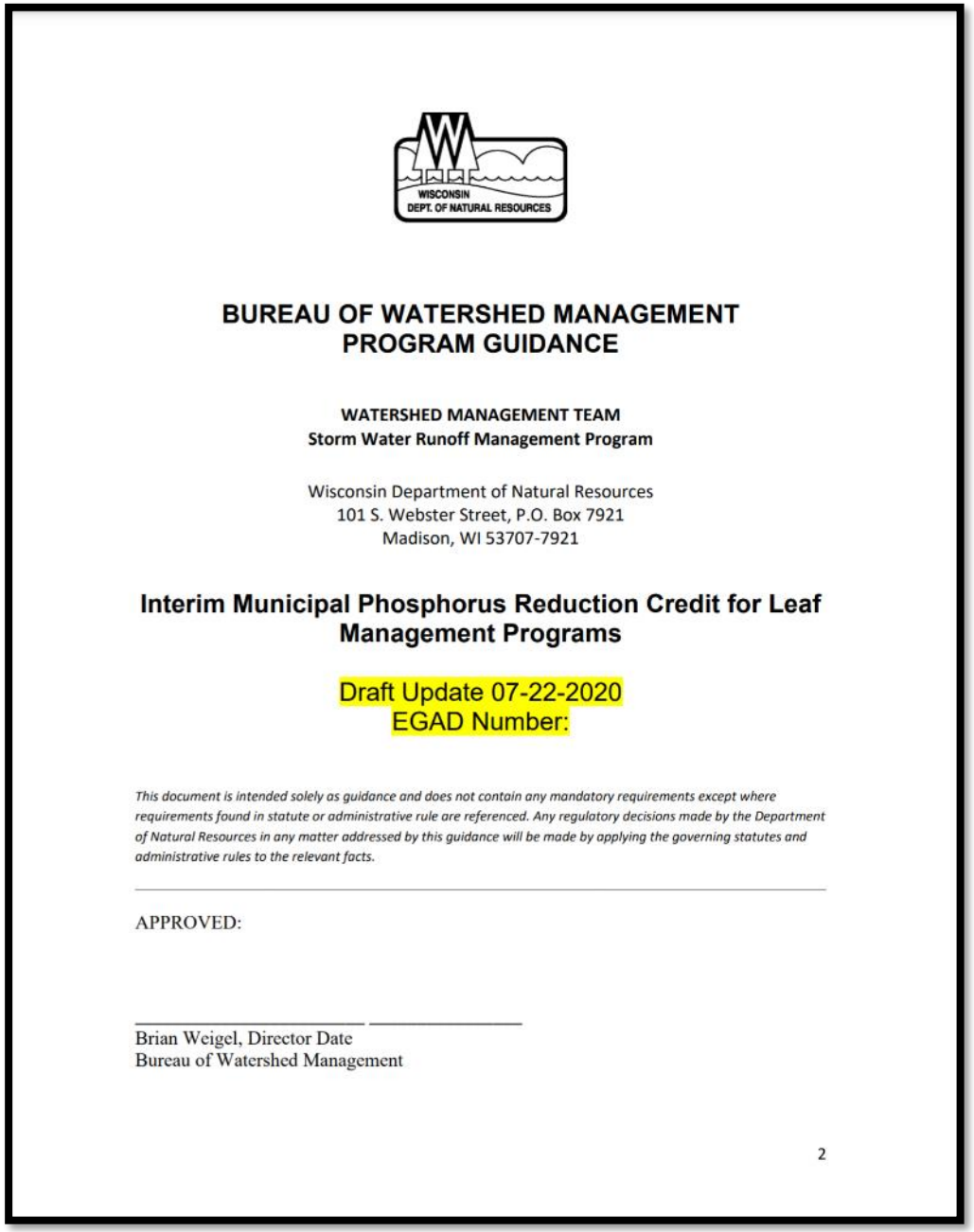
- Regression models
  - phosphorus is closely related to leaf mass but how do you predict when leaves fall?
- WinSLAMM
  - already has street cleaning. Can modify for leaf collection
- i-Tree
  - will soon have ability to include nutrient content of leaves by species for water quality

How does leaf management influence downstream BMP performance?

By reducing phosphorus at its source, do other BMPs gain or lose efficiency?

- Wet ponds
- Are models “double-dipping”?

https://images.app.goo.gl/tk68gkJxcPYCKe2x5



WISCONSIN DEPT. OF NATURAL RESOURCES

BUREAU OF WATERSHED MANAGEMENT
PROGRAM GUIDANCE

WATERSHED MANAGEMENT TEAM
Storm Water Runoff Management Program

Wisconsin Department of Natural Resources
101 S. Webster Street, P.O. Box 7921
Madison, WI 53707-7921

Interim Municipal Phosphorus Reduction Credit for Leaf Management Programs

Draft Update 07-22-2020
EGAD Number:

This document is intended solely as guidance and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes and administrative rules to the relevant facts.

APPROVED:

Brian Weigel, Director Date
Bureau of Watershed Management

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Questions?

Bill Selbig
USGS – Upper Midwest Water Science Center
wrselbig@usgs.gov

https://dnr.wisconsin.gov/sites/default/files/topic/Stormwater/draft/PN_Draft_Revised_Leaf_Management_Credit_07-22-2020.pdf